INDOOR AIR QUALITY ASSESSMENT

Brockton Public Library
304 Main Street
Brockton, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Harry Williams, Director of the Brockton Public Library (BPL), the Massachusetts Department of Public Health's (MDPH), Center for Environmental Health (CEH), was asked to provide assistance and consultation regarding indoor air quality in all of the Brockton Public Library (BPL) facilities. On February 23, 2005, a visit to conduct an assessment was made to the main BPL located at 304 Main Street, Brockton, MA by Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by Junior Custodians Steve Levy and Mark Smith during the assessment.

The main BPL, located in downtown Brockton, is a three-story brick structure built in 1913, originally as a high school. Extensive renovations and an addition were made to the BPL from 2001 to 2003. The main floor of the library contains the circulation desk, administrative offices, break room, open stack areas, restrooms, and computer stations. The first floor contains the children's library, office space and a multi-purpose room. The top floor contains a reference section, young adult area, art room, offices, historical room, microfilm viewing area and several small tutorial rooms. The boiler plant and electrical rooms are located in the basement. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, temperature and relative humidity with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The BPL has approximately 30 employees with up to 300-400 members of the public visiting on a daily basis. Tests were taken during normal operations and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate ventilation at the time of the assessment. A heating, ventilating and air conditioning (HVAC) system provides mechanical ventilation. The system consists of four rooftop air handling units (AHUs) (Picture 1) that are ducted to a combination of fan coil units (FCUs) and variable air volume (VAV) boxes located above the ceiling tile system throughout the library (Picture 2). The system is electronically controlled from a central computer station by BPL staff. Airflow and temperature are controlled locally by the FCUs and VAV boxes that have control dampers that open or close, depending on the temperature demand for a serviced area. These systems were operating during the assessment, however, AHU 4 was recently reported to have control issues that were still being investigated by the BPL's HVAC vendor.

Exhaust ventilation is provided by rooftop exhaust motors (Picture 3) ducted to ceiling-mounted vents throughout the building. This system was operating during the assessment. In one case, the children's library has a ceiling-mounted air diffuser located

directly next to an exhaust vent (Picture 4). As a result, the supply air from the diffuser is drawn into the exhaust vent without circulating, a condition known as short-circuiting.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The date of the last systems balancing should have occurred when building renovations were completed in 2003; however this could not be confirmed by BPL staff. Mr. Williams reported that BPL staff has been working with several different HVAC vendors since the building reopened in 2003 to adjust the HVAC system, due to on-going employee comfort complaints and system control issues.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows (BOCA, 1993; SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur,

leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature measurements ranged from 71° F to 75° F, which were within MDPH comfort guidelines. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. On-going temperature control complaints in a number of areas were expressed to MDPH staff during the assessment. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. As discussed, BPL staff has been and continue to work with their HVAC vendor to identify and correct areas where temperature control is problematic. This includes a possible upgrade to more user-friendly and manageable software and computer controls.

The relative humidity measured in the building ranged from 18 to 22 percent, which was below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity

levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water-damaged/bubbling paint was observed in the stairwell leading to White Avenue (Picture 5). Water damage is most likely the result of water penetration through the building envelope, primarily around the cylindrical architecture above the White Avenue entrance (Picture 6). Although water damage appeared minimal, repeated water damage to porous building materials (e.g., gypsum wallboard, wood) can result in microbial growth. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur.

Other Concerns

Several other conditions that can affect indoor air quality were noted during the assessment. Libraries in general, have a large number of flat and irregular surfaces (e.g., book shelves, books) that provide a source for dusts to accumulate and are difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be removed and/or be cleaned periodically to avoid excessive dust build up. BPL

staff had recently purchased a vacuum equipped with a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner to help improve dust control.

AHUs are equipped with filters that strain particulates from airflow. According to BPL staff, filters are changed three to four times a year. However, the type of filters installed provide minimal filtration of respirable dusts (Picture 7). In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (a condition known as pressure drop), which can subsequently reduce the efficiency of the AHU due to increased resistance. Prior to any increase of filtration, each AHU should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

The custodial office on the first floor is used for storage of a number of cleaning chemicals/agents. These areas are normally equipped with local exhaust ventilation to remove odors. The exhaust vent for this area is located in a closet used for computer network equipment. MDPH staff recommended installing a passive vent in the wall (Picture 9) to allow air to flow from the custodian's office into the closet and subsequently be removed by the local exhaust vent.

Staff in the children's library complained of eye and respiratory irritation, primarily at the workstation behind the circulation desk. The work area is located directly under the

exhaust vent for the HVAC system, which will tend to draw air and airborne particulates (e.g., dust, paper fibers from cutting, odors) past staff working there. Mr. Levy recommended relocating the work area to an alternate location behind the circulation desk away from the air stream of the exhaust vent.

Finally, BPL staff reported that a boiler malfunction had occurred several months prior to the MDPH assessment. At time of the boiler malfunction, several gallons of glycol, a coolant material, reportedly spilled onto the floor. As a result, odors migrated into the adjacent elevator shaft room and stairwell to the first floor. The movement of the elevator in the shaft can act like a piston, pressurizing and depressurizing air in the elevator shaft, which can then force and draw odors into other areas of the building. At the time of the assessment the boiler had been repaired and the glycol spill was cleaned and no evidence or lingering odors were detected. BPL staff did, however, ask advice on corrective actions in the case of any future boiler problems. These suggestions are listed in the Conclusions/Recommendations section at the end of this assessment.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Continue working with HVAC vendor to make adjustments to the mechanical ventilation system, which may include software and computer control upgrades to improve the comfort of occupants.
2. Relocate exhaust vent in children's library (Picture 4) away from supply vent to prevent short-circuiting.

3. Consider balancing the mechanical ventilation systems building wide to ensure appropriate functioning of the complex mechanical ventilation system. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994).
4. Consider providing formal training to *multiple* individuals to create redundancy to ensure proper operation and maintenance of the HVAC system.
5. Consider increasing the dust-spot efficiency of HVAC filters. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.

6. Relocate work area behind circulation desk in children's library away from vents.
7. Consider consulting with an architect, masonry firm or general contractor regarding the integrity of the building envelope, primarily concerning water penetration through the exterior wall at the White Avenue entrance.
8. Repair leaks and repair/replace any water-damaged materials.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner *in conjunction* with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

10. Install passive vent in upper wall of custodial office on first floor, as shown in Picture 8, to provide exhaust ventilation.

11. Seal the boiler room doors from adjacent areas (elevator shaft, stairwell, etc) (Picture 9) with polyethylene plastic sheeting and duct tape on both sides of the boiler room door in case of another glycol spill. In addition, seal opposing sides to provide a duel barrier. The area should also be depressurized by deactivating the HVAC motor shown in Picture 10 and by venting the room out the make-up air vent using flexible ductwork and fans (Picture 11).

12. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-1601 et al.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001.

Picture 1

Rooftop Air Handling Unit

Picture 2

Fan Coil Unit above Ceiling Tile System

Picture 3

Rooftop Exhaust Motor

Picture 4

Supply and Exhaust Vent Directly next to Each Other in Children's Library

Picture 5

Water Damaged/Bulging Paint in White Street Stairwell

Picture 6

Architecture Outside of White Street Entrance Where Water Damage has Occurred

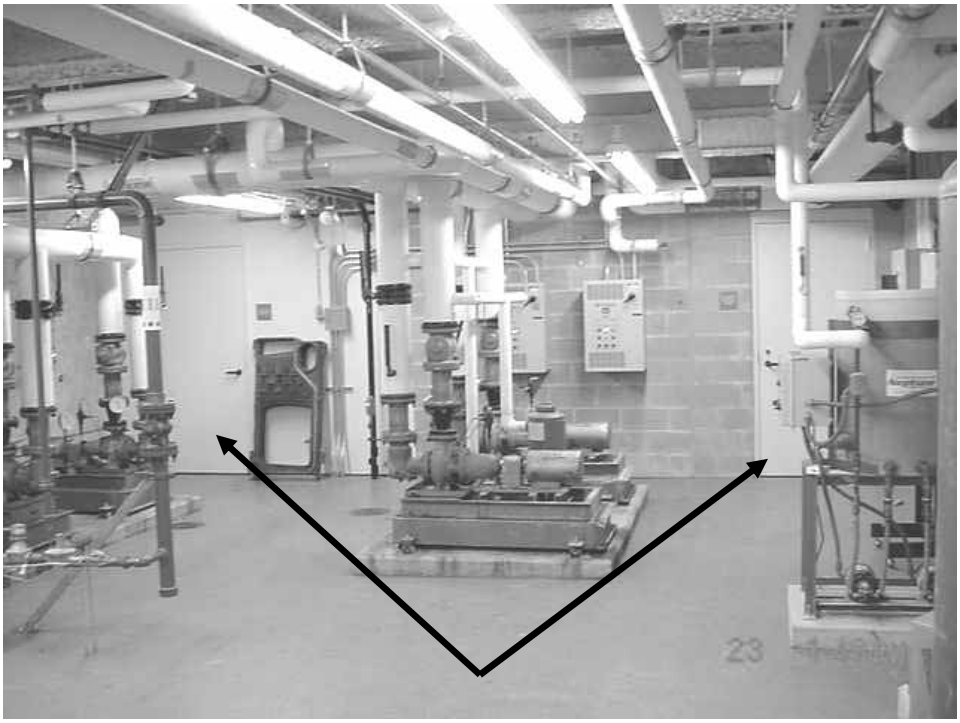
Picture 7

Fibrous Mesh Filters in Rooftop Air Handling Units

Picture 8

Custodial Storage Office, White Box Indicates Location Recommended for Passive Vent

Picture 9

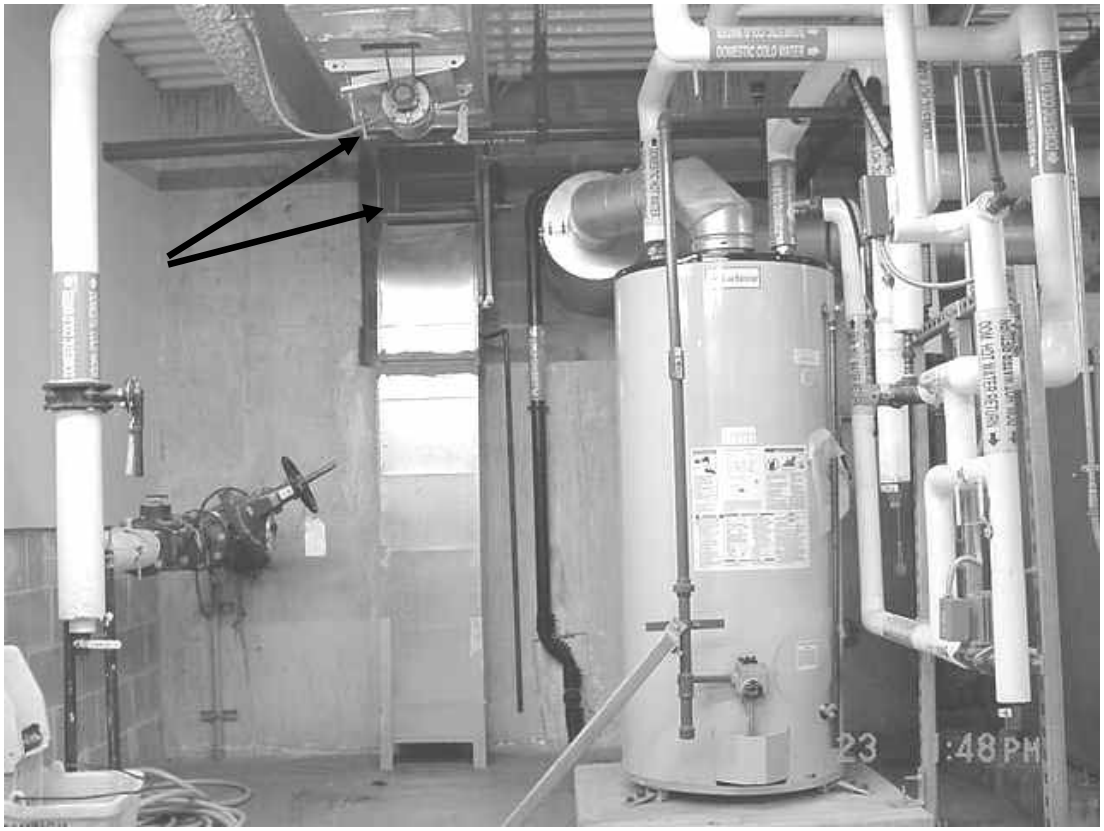


Doors in Boiler Room, Stairwell Door to First Floor not Shown

Picture 10

Close-Up of Boiler Room Make Up Air Vent and HVAC Motor

Picture 11



Long View of Boiler Room Make Up Air Vent and HVAC Motor

TABLE 1

Indoor Air Test Results – Brockton Public Library East Branch, 54 Kingman St., Brockton, MA – February 23, 2005

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Background	327	47	35					Atmospheric Conditions: scattered clouds, NW winds 10-15 mph, cold
800 Stacks	455	75	20	1	Y	Y	Y	
Young Adult	518	75	19	3	Y	Y	Y	
Computer Station/Circ Desk	593	75	20	23	N	Y	Y	
Computer Lab/Microfilm	522	75	19	17	Y	Y	Y	
Microfilm Storage	411	73	18	0	Y	Y	Y	
Historical Room	422	73	19	1	Y	Y	Y	Humidification system-not installed
References Office	413	73	19	1	Y	Y	N	
Circ Desk Main Lobby	486	73	19	5	N	Y	Y	

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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						Supply	Exhaust	
AV Room	466	72	19	0	Y	Y	Y	
Periodicals	492	71	19	2	Y	Y	Y	
Stairwell White Ave								Water damaged paint-evidence of water penetration
Fiction	594	71	21	4	Y	Y	Y	
Sci Fi/Fantasy	501	71	20	2	N	Y	Y	
Custodian Closet	581	73	22	0	Y	Y	N	Rec passive vent in upper wall to data closet
Circulation Work Room	429	73	19	1	Y	Y	Y	Plants
Dept Head Circulation Office	400	73	18	0	N	Y (2)	Y	
Administration Offices	395	72	17	1	Y	Y	Y	
Assistant Director	425	73	18	1	Y	Y	Y	

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						Supply	Exhaust	
Kitchen	514	73	19	3	Y	Y	Y	
Computer Lab 1st Floor	400	71	18	0	Y	Y	Y	
Children's Circulation	523	71	20	2	N	Y	Y	Work station directly below exhaust vent-rec relocating
Children's Offices	503	72	19	0	N	Y	Y	
Picture Books	505	72	19	3	Y	Y	Y	
Computer Station	490	72	20	6	N	Y	Y	Exhaust vent in close proximity to supply vent (short-circuiting)
Multi-Purpose Room	450	72	19	0	N	Y	Y	

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